THE PROCEEDINGS
of
THE INSTITUTION OF PRODUCTION ENGINEERS

The Official Journal of the Institution of Production Engineers

Members are requested to correspond with the Editor upon matters of general interest. Letters may take the form of descriptions of unusual plant or tools, workshop methods, production problems or organisation systems. Only in exceptional circumstances will proprietary articles be dealt with editorially. Manufacturers wishing to draw the attention of the Institution to the merits of their products are invited to use the advertisement columns of this Journal. All correspondence should be addressed to the General Secretary, Institution of Production Engineers, 40, Great James Street, Bedford Row, London, W.C.1.

VOL. X. SESSION 1930-31. No. 3.

FORD PRODUCTION METHODS.
Paper presented to the Institution, Manchester Section, 13th October, 1930, by Thomas Gorst, (Member.)

[*Also presented Birmingham Section, 15th October*, 1930 ; *Coventry Section, 12th November*, 1930; *Luton, Bedford and District Section, 10th December*, 1930 ; *Joint Meeting of Birmingham Section and Wolverhampton and District Engineering Society, 15th December*, 1930 ; *and Glasgow Section, 24th February*, 1931].

Introduction.

THE Company whose production methods we are setting out to discuss is the largest industrial organisation that the world has yet seen. Its manufacturing activities have assumed dimensions and importance hitherto undreamed of. Its products and merchandising organisation have reached every corner of the civilised world with a steadily increasing intensity, and its factories are to be found in upwards of twenty different countries, representing important contributions to the industrial life of those countries. Its factories have become the Mecca of

scientists and industrialists all over the world, and have created a permanent imprint on the social system by the application of its industrial policies. It is demonstrable that the establishment of its plants has invariably had the effect of steadily raising the workers standard of living, has stimulated local industries, created new ones, and been the direct means of increasing employment in the many trades which directly and indirectly serve it. It is now extending its activities in many and diversified directions in all parts of the world, and its activities are so vast and widely flung that the baldest truth, simply stated, is in danger of being regarded as over coloured and exaggerated.

There are upwards of eighty plants of varying size and importance so situated geographically as to secure the utmost possible economy in the manufacturing, assembling, and distribution of its product. These plants are employing from a few hundred workers in the smaller ones to over 100,000 workers in the largest one, whilst we are at present building at Dagenham, near London, what will be the largest motor car factory in Europe, whose factory area will approximate one million square feet, and whose production is expected to reach 200,000 units per annum, and the number of workers employed in the region of 20,000. In its wide and constantly expanding activities it already includes upwards of fifty industries, amongst which are to be found coal mining, iron ore mining, blast furnaces, steel rolling mills, timber lands, steamship lines, railways, glass, leather, rubber plantations and manufacture, and many others, and in many cases it can safely be claimed that it has the largest output in the world in that class of activity. In its entry into the industries which produce raw material and transport, it has not only applied its own methods in securing the lowest possible cost at the source, but has also secured the incalculable advantage of avoiding the difficulties created by market fluctuations, labour difficulties, and the absolutely essential security of steady and uninterrupted production at all times, dictated by its own convenience and production policies. The steady supply of raw material having been secured, it is able to go into the market with increased buying power, and by having its own assured supplies, can not only successfully counter the possibility of "rigged" markets, but can take advantage of whatever market fluctuations are favourable.

Trading Policy.

Its trading policy is worthy of some comment in that the Company attempts to supply in its product not merely machinery but economic transportation which shall at all times be kept in steady service to its owners. It is the policy of the Company constantly to concentrate on the reduction of production cost, keeping its selling cost in proportionate ratio, thus passing on the benefits to the consuming

public. The establishment of adequate service facilities is the most cherished ideal in its trading policy, and is the Ark which is borne before all the company's activities in every direction.

Measurement and Gauges.

No engineer will need telling that standards of measurement and suitable inspection gauges are of vital importance, not only in securing uniformity and consistency in current production, but also in ensuring that parts produced at any time will be accurate enough to fit into place with certainty, and the Company's activities and research in this subject, the general adoption of Johannsen gauges, and the acquisition of the rights and secrets of this marvellous production—the inventor of which is now one of the active members of the Company's research staff—is a most interesting part of the Company's manufacturing history. The world famous Johannsen gauge blocks are therefore well known tools in all our establishments, and their use has conferred standards of measurement which can be relied on with confidence, whether it be in Manchester or our most isolated plant.

We know that perfect definite measurement is unattainable, since measurement and the minuteness of the divisions in measurement can be extended into the infinite. The scientist says that no two grains of sand are alike, and it is equally true that no two articles can be produced exactly alike. This produces the question for the engineer as to what extent of error can be allowed, or how far is it necessary to extend the limit of accuracy in order to secure the mechanical perfection requisite to ensure uniformity production and accurate working parts which shall thereby be endowed with reasonable certainty of long life.

Many of the manufacturing parts have to satisfy dimensions of a limit of accuracy running into the 1/10,000th part of an inch, and this measurement is difficult to understand. Let us take for example a human hair, which is approximately 2/1,000ths of an inch in diameter; then 1/10,000th part of an inch would be equivalent to splitting that hair into twenty equal divisions, and 1/100,000th part of an inch—and we have gauges to this limit—would be equal to splitting the hair 200 times. A further example, take say the highest building in the world—which is, or was, the Woolworth building, 750 feet high—let us say for experiment 10,000 inches; then 1/10,000th of an inch is represented by one shilling lying against the Woolworth building.

It is worth mentioning, although it may be a little hard to realise, that Johannsen possesses measuring instruments and methods by and through which he can detect differences of one millionth part of a millimetre—a feat that no one else in the world has equalled. In this accomplishment he stands in a class by himself, and is entitled to the reference as the world's foremost authority on measurement.

This accomplishment seems miraculous, since every mechanic knows the difficulty of producing a flat surface, but when to this is added the necessity of finishing that surface in relation to the one already produced on the other side, to this fine division of accuracy, it will be seen that whatever method is employed in their production —which is, of course, a secret—the lapping, or whatever it may be, must stop at a certain instant of time, and at that instant the surface must be flat, uniform, parallel, and, of course, with the distance from the other face, accurate within the limit intended.

The foregoing is mentioned with some little pride, since the acquisition of the secrets of this marvellous production and its manufacturing rights have been the means not only of laying that bogie of engineering, the achievement of a reliable standard of measurement, but have also made those standards common currency to the many manufacturing departments in our factories.

In the production of items which have to satisfy such exacting limits as to more resemble gauges than production material, jigs and fixtures have to be extensively used, and are designed with regard to not only the immediate production with which they are concerned, but also to form inspection jigs for the product of preceding operations. Successive operations are in many ways so designed that one or more faces shall be a check or datum line for the machining of a flange, or the multi-drilling and tapping of holes.

Steel specifications are the product of years of experience and research in deciding the most suitable steel for the various purposes which have to be satisfied, with the added necessity of keeping down weight while possessing the requisite degree of toughness and strength. Cost also enters into this equation, and this means that no raw material of any kind can be admitted into stock for production until it has first satisfied inspection and laboratory tests, which consist of the usual physical and analytical examinations. All incoming material on which work has been expended has to satisfy inspection appropriate to its nature. Where these are working parts made to precision limits, every piece must be examined and every dimension checked.

Many examples of ingenuity in the design of simple inspection jigs are installed, a description of one of which will be an indication of their nature. Enormous quantities of steel balls are manufactured which, after passing the tests for size, are tested for hardness by rolling through from the container down an incline, from which they fall on to an anvil, the height of the rebound determining whether they are fit for use. If the ball is hard it rebounds the necessary height to carry it into the O.K. container, while if too soft it fails to achieve the height and falls into the rejection basket. To watch this simple device work is an almost uncanny experience, which from the speed and certainty at which it operates, seems almost

endowed with the ability to think. This, of course, is a simple example of the scleroscope test.

Tools.

A considerable amount of research is directed towards the tools which are used in our plant, cutting speeds and feeds, types and sizes of tools and machines most suitable for their work, and in many other ways intense consideration is applied to the usual problems of an engineering workshop, but which in our case are very much intensified by reason of the large production, the close precision limits, and the colossal quantities of material to be handled, this latter lending an importance to details which would in other circumstances be of little consequence.

Conveyors.

The general use of conveyors is now well understood, and no longer a unique aspect of our production as was at one time the case, but it is known to be one of the outstanding tools for economical and controlled production.

Conveyors provide transport of material, conserve space, give effective control to production in both quantity and quality, ensure adequate and synchronised supplies of parts worked and to be worked upon, and are a most effective instrument in the reduction of capital cost as represented by the value of work in progress, and it can be claimed that the advantages of conveyor production have been applied in many unusual ways which are probably unique. Some details of one or two examples will follow. Conveyor production is, however, very much misunderstood, and is popularly supposed to be a mechanical means of aiding production, in the use of which everything is sacrificed for speed, and a picture is conjured up of frantic men throwing parts together with a feverish haste and hoping for the best. This is about as far from the truth as it can well be. In the first place, it would be decidedly unwise to drive the men to a point where they become over-tired and consequently careless, and it will need no explaining that moving conveyors demand very fine limits of accuracy in the parts which are to be assembled on them, since scraping, filing, fitting, and trying cannot be resorted to to compensate for or correct material which is not to within specified dimension limits.

In our workshops conveyors are used for many purposes, overhead conveyors for transport; bench conveyors; belt conveyors for reception and collection of manufactured parts from such machines as punch presses, automatics and others; below ground conveyors for the removal of swarf, cuttings, and other waste from manufacturing material, which is transported to and handled by baling machines, glass manufacture; artificial leather manufacture; pouring castings; and many other purposes.

In many of our machine shops it will be seen that transport of material by means of overhead conveyors is developed to an extraordinary degree, the overhead chains being both the means of supplying the worker with the parts to be machined, and the outlet for the parts after machining. Fairly considerable quantities of material must be handled to justify this economically, but where the volume of work is not sufficient to justify expensive equipment, then the ordinary gravity chute and roller slide are not despised.

Motor Assembly.

Our motor assembly conveyors represent an ordinary type of bench conveyor in which the several needs of the workmen and the many and varied operations of building a complicated piece of mechanism such as is represented by a complete motor are catered for. Pneumatic lifting tools are supplied at strategical points, not only for relieving the labour of the worker, but also for turning the motor over, lifting into and out of testing stands, and other and similar purposes. Electrically driven speed wrenches hang overhead balanced by suitable counter weights within handy reach of the operator at the exact moment required. These are suspended in such a way that the necessary amount of travel is possible to coincide with the movement of the conveyor over which they operate. Supplies of material such as nuts, bolts, pins, etc., are usually to be found in boxes either suspended immediately below the bench level, or in boxes within handy reach, the ultimate objective being the entire elimination of lost motion on the part of the worker.

Sub-assemblies and parts such as piston and connecting rods, camshafts, crankshafts, valves, etc., reach the conveyor exactly synchronised with the assembly in which they are to find their place. Small enclosed rooms are arranged through the windows of which one can see men busily engaged in checking wrist-pins, pistons, and the connecting rods, and the rod and piston assembly. The purpose of these rooms is to check the material and assembly at a constant temperature, since the parts are expected to satisfy limits within 4/10,000ths of an inch, and it was found that before installation of these rooms variations of temperature were sufficient to cause some embarrassment in this job.

Constant temperature checking and its significance.

The importance of this constant temperature checking will be better understood when it is explained that different kinds of metals are used, and as is generally known, variations of temperature do not have the same effect upon them all. The piston, which is Lynite, expands faster than steel under increased temperature, while the connecting rod does not expand as much as the piston pin because of its bushing of bronze. The standard temperature

of 68 degrees has been set by C. E. Johannsen as the proper temperature for these rooms, and incidentally it is at this temperature that Johannsen gauges are adjusted and calibrated when they are manufactured.

The results of experiments proved interesting. When an additional 13 degrees had been added to the normal 68, it was found that the connecting rod increased 1/10,000th of an inch, the piston 2/10,000ths of an inch, and the wrist-pin 1/10,000th of an inch. At 90 degrees the changes increased and varied as follows :—

Connecting rod	14/100,000ths of an inch
Piston	33/100,000ths of an inch
Wrist pin	15/100,000ths of an inch

At 500 degrees the following variations would be noted :—

Connecting rod	27/10,000ths of an inch
Piston	65/10,000ths of an inch
Wrist pin	28/10,000ths of an inch

It will be seen therefore that where we are grading material to limits of measurement represented by 3 and 4 10-thousandths of an inch, the temperature becomes a very important factor in the equation.

Cylinder Block Assembly.

During the manufacture of the cylinder block the main bearings are prepared by close machining for the reception of the crankshaft. After the bearings have been proved to be in line and uniform in diameter with the crankshaft, the main bearing caps are bolted down tight and the motor block then pays a brief visit to a burnishing machine where the crankshaft is run for a period of about twenty seconds. This produces a glass like surface on the babbitt bearing, and nothing remains to be done beyond removing the caps for examination, cutting oil grooves, and inserting the necessary .0015 shim for working clearance. Many other interesting operations could be described which would be well worthy of inclusion if time permitted.

After completion, the motor has finished its journey on the bench conveyor on which it commenced its life, and has now reached an endless conveyor running on the four outside edges of and including a space devoted to and equipped with two lines of test stands, these stands being so designed as to reproduce the normal condition of the motor when at work in the chassis. The purpose of the conveyor running around is exactly similar to the supply conveyors in machine departments, and contains a mixed supply of untested and tested motors handy for the operators on the test stands and merely differentiated by the labels that they carry. After this visit to the test stand, and having satisfied the inspectors as to their fitness for inclusion in the chassis, the motors are again hoisted on to the "run-about" conveyor, and in continuing their journey pass

a supply point where they are diverted to the main chassis assembly conveyor, and there we will leave them for a few minutes.

Chassis Assembly.

The chassis erection is similar in many respects to the job which has already been described, except that naturally transport and supply problems are a little different in their nature and size. It is also a little difficult to say just where the chassis assembly begins as there are many scores of subsidiary operations beginning in various parts of our shops which at completion have arrived at the chassis assembly conveyor. This fact is of great importance, and wherever and whenever it can be consumated, parts for sub-assemblies as they are near completion are at the same time making their way towards the point at which they are required in the erection of the chassis. This is true of the chassis frame, rivetting and painting, the enamelling of wheels, mudguards, and other similar parts, the manufacture and testing of electrical apparatus, steering gear, front and rear axle parts, and a host of other parts the supply of which must be maintained and synchronised at all times. Exacting inspection requirements must be satisfied in the various assemblies and parts to ensure that they fit together accurately in the first place and ultimately will function satisfactorily as a complete unit.

Conveyors are devoted to the production of the several kinds of rear axles and front axles which are delivered to the chassis assembly conveyor, and at the completion of their journey they are met by the motor which we left on a feed conveyor on its way to the point of its assembly into the chassis frame. The journey is continued, various parts being added as and when required, and after completing about three quarters of the distance on the main conveyor, the whole is met by a complete body, the history of which we will briefly examine before proceeding further.

Body Production.

The story of the body production presents a similar difficulty to the one referred to in the chassis assembly, namely, deciding at which point the story should begin. Several types of bodies are produced, and the passenger models are almost entirely constructed of steel. The production of the steel parts represents an enormous outlay of capital in tools and presses, and much ingenious designing of both tools and the parts, the result being a combination of lightness, strength, and finish, which could only be secured by tremendous resources such as are applied to its production. We, however, will concern ourselves with its production from the point which begins with the rivetting and welding of the various panel and part assemblies.

Cowl Welder.

The front end, which is common to several types of passenger bodies, and consists of petrol tank, side panels, coupe pillars and windscreen frame, is assembled together in a welding jig which is not only a somewhat elaborate piece of electric welding mechanism, but is also a jig which confers a high degree of accuracy in the securing together of the parts which are put together in it. The spot welding of the sides and front of cowl is accomplished by means of hand operated electrode holders with which are incorporated push button clapper switches controlling the primary current to the welders. The machine includes two transformers for sides, and one for front of cowl. The production is approximately ten minutes each, and the number of welds per cowl is seventy-two.

Jigs known as body bucks are situated at the commencement of conveyors, and at the point at which bodies first take definite form as such, the purpose of the jigs being to locate and hold all important dimensions while rivetting and welding are completed to a point at which it is safe to send the skeleton body along the conveyors for completion of the several operations that go to its construction. This is done on conveyors which support the body at convenient working height, and when completed the body is transferred by mechanical means to an overhead conveyor chain on which it remains through the several operations required in the cellulose finishing which is applied. This represents a triumph of careful synchronising of speeds, times, and heat. The basis of this somewhat elaborate calculation was the product required per working day. From this was evolved the travelling speed of the overhead chain, the several operations required, painting, rubbing down, the application of the several coats, the length of time required for each to dry, the heat of the oven, and the length of the oven, to give the requisite drying time, were all carefully calculated, the whole presenting an elaborate piece of conveyor work which has proved remarkably efficient and economical. Near the end of the painting operations the bodies again find their way on to platform conveyors for the trimming and finishing operations, and at the end of their journey have arrived under the lifting apparatus at the chassis assembly conveyor, by means of which they are transferred on to the chassis for the journey before the whole becomes a complete car, which after passing through the usual testing, inspection, final adjustment and tuning, goes on to the sales stock for dispatch by road or rail.

Glass Manufacture on Conveyor.

Plate glass seems about as unlikely a subject for manufacture by conveyor methods as could well be imagined, yet it is being quite satisfactorily and economically accomplished at the rate of something like 11 million square feet annually. The batch is melted

in furnaces each with a capacity of 408 tons of molten glass, the temperature being a melting heat of 2,500° Fahrenheit, and a refining heat of 2,300° Fahrenheit. The glass flows out in a continuous stream on to a slowly revolving iron drum which passes it under a roller which determines the thickness of the sheet into which it is rolled. It moves about 30 to 34 inches per minute, and the conveyor on to which it has now been deposited, which is 442 feet long, represented something of a problem in the alignment and smooth running of such a machine, the movement of which must be absolutely even so as to prevent the existence of strains which would crack the glass. During its progress along the conveyor it passes under a series of grinding and polishing discs to a gradually diminishing grade until final polishing by the use of rouge, eight grades of sand and six grades of emery being used in the grinding. At the end of the conveyor the glass is cut into sheets, turned the other way up, after being set on the return conveyor in a mixture of plaster, it commences the return journey, the process of grinding and polishing being repeated on the reverse side.

Foundry.

The foundry at our River Rouge plant, which is the largest in the world, covers about 30 acres and is unquestionably the most elaborately mechanised example of its kind. Upwards of 2,000 tons of iron per day is poured, not one pound of which is lifted by hand. The usual method of carrying the iron to the mould is modified to a great degree by the use of conveyors which carry the moulds to the pouring point, and afterwards continue their journey to the shake out station, where the casting is shaken loose to continue its journey to the tumbling barrels or other appropriate destination en route to the machine shop. The sand falls through a grating on to a belt conveyor which takes it back to a point at which it is mixed with fresh sand in the right proportion, from which it is fed again by mechanical means to the hoppers, from which the moulders are supplied. This process will be shown in some detail on the film which is to follow.

Before leaving the subject of conveyors, it might be well to introduce a word about the supposed monotony of this type production. There is a totally erroneous idea existing that continuous production, which is so pronounced a feature of our factories, is of necessity bound to be of a deadly monotonous nature. It should be pointed out, however, that the introduction of continuous production did not coincide with the use of it as applied to the building of motor cars, as most people seem to believe, but has been a feature of cotton mills, woollen mills, and many other types of manufacture for some generations, and one might add, the old fashioned spinning wheel of long ago must have been a prime example of monotonous employment. Our experience shows that

there is nothing whatever in this popular belief, our employees finding their work just as interesting as is likely to be the case in any other manufacturing operation.

Mr. Ford has said "That we are as a matter of policy against hard work. There is a difference in a man working hard, and hard work. A man working hard will produce something, whereas hard work is the least productive sort of labour . . . . It is not possible except in the crafts which approach the arts for a man to earn a really good living with his hands. It is therefore a matter of industry so arranging work that it can be productive and profitable."

It is an important fact worthy of the attention of our modern industrialists that continuous methods of production along the lines which have been described with some detail, make it possible to produce accurate and highly finished examples of the engineers' art with so-called unskilled labour, since the sub-division of operations can be so extensive as to enable an inexperienced man not only to learn his job thoroughly, but also to acquire a manual dexterity which is not possible in the application of the old time craftsman methods of production.

Piston Production.

We will now leave the general question of conveyors and describe one or two special features in the manufacture of parts which may be of interest.

The piston is an important unit which must be as exact in size and weight as can be achieved, and ordinary machining methods are used to accomplish this, but the method of ensuring a close limit of weight offers a point of some interest. The piston is completely finished except for weight, and reaches a special machine for the purpose of weight correction. The operator places a piston upon a delicate scale to determine the amount of its overweight. On top of the machine is another scale which is in mechanical contact with a so-called chip-cup. The operator sets the machine scale to a reading corresponding with the overweight of the piston, the piston being placed in position and the machine started, the metal chips bored from the inside of the piston drop in the cup, and when the weight of the chips equals the overweight, the machine stops, the whole operation taking a few seconds.

Crankshaft Manufacture.

The crankshaft of a modern motor engine is probably the most important unit of the entire machine, since upon its accuracy depends, to a very great degree, the proper functioning of the motor. At the Dearborn plant of the Ford Motor Company there are 200 modern crankshaft grinding machines, and it likely that some of the first crankshaft grinders were installed by Ford engineers. Crankshaft grinding can be divided into four major epochs, first,

in the days when the shafts were turned and filed, then came the period when the shafts were rough turned and ground, later the somewhat spectacular process of grinding crankshafts from rough forgings was developed, but after exhaustive experiments it was found that turning followed by grinding produced the best shaft, and that, of course, is the method in general used at the present time, and is no exception in our factories. The Ford crankshaft incorporates nine ground fits all told, which are held to fine limits of accuracy not only in their diameter and length, but in their relationship with each other. They reach the grinding department 0.050″ oversize, and .025″ is removed from each diameter in each of two operations—semifinish and finish. The first grinding operation consists of semi-finish grinding the three main bearings. Further grinding operations consist of finish grinding the pins by means of a Landi hydraulic double wheel crank pin grinder. The wheels are manufactured of Alumina, 36″ diameter, 1.626″ wide, 36 to 46 grit. The peripheral speed about 6,500 feet per minute. The shaft is held in offsets ; the heads carrying these offsets are connected with a drive shaft at the front operated simultaneously, imparting a drive from each end of the shaft. During grinding, the operator checks the size of the work by means of a Pratt gauge which is graduated to read to 10,000ths of an inch, and is in position during the grinding operation, so that by watching the gauge the operator can grind to very close limits without the necessity of stopping the work to test with micrometer or snap gauges. The gauge is fitted with three diamond points, one of which is on the end of the rod that actuates the dial reading mechanism.

With the work in place done, the operator having finished the two pins that lie in the same plane, then re-location is necessary for the two that are 180° opposite. Gauges are used for locating the work in these positions. With the use of the double wheel machine it is obvious that considerable time can be saved. It was at one time thought that a ground crankshaft with its pins and bearings polished a little to remove the " grinding fuzz " was accurate enough for any purpose. We now know, however, that a much more highly finished surface is not only desirable, but can be produced, and this has led to the development of special machines for honing the finished surfaces after grinding. Schraner honing machines are used for this purpose. These machines are fitted with seven arms, each of which carries a head fitted with six honing stones, which are carbide of silicon, while the lubricant used is ordinary paraffin. Half a minute is generally sufficient to remove grinding marks and produce a highly finished surface. This, however, is not the final operation, as after the bearings are honed the shafts go to another battery of machines having heads fitted with a fine 320 grit Alumina paper. This machine is interesting, as each head is fitted with a magazine roll fitted for the paper so that a fresh

section is pulled and used for each pin. The limits of accuracy on the pins and main bearings are .00025" for out of round and taper, and frequent inspections are made during its manufacture to avoid expensive rejections of parts on which considerable work has been expended.

After the crankshaft has safely survived its very exacting final inspection, an important operation follows, on the Gisholt crankshaft balancing machines which are the result of much study in perfecting a machine for this particular purpose. These machines indicate just where the shaft is out of balance dynamically, and indicate the exact place to remove metal to compensate for the error. By means of a carefully worked out table, the operator is told just how deep to drill, and the size of drill necessary to overcome the error, the drilling machine being fitted with a micrometer depth gauge of the dial type to ensure that no excess metal is ever drilled away. The balancing operation is accomplished by balancing the shaft to rotate over four rollers in such a way that the least out of balance movement is imparted to the rollers and from them to the registering mechanism, when it is corrected as above indicated.

Rustless Steel.

The use of rustless steel in exposed metal parts of the Ford car necessitated the installation of new machinery in the Ford plants and the development of new methods in drawing operations.

Rustless steel, an alloy of chrome nickel and iron, is about twenty per cent. more ductile than ordinary steel but the ductility decreases faster during the drawing stages. Therefore, the various operations must be continuous. Furthermore rustless steel is much stronger and stiffer than ordinary steel and, while the dies are of the same design as those used in the forming of ordinary steel, greater allowance must be made for spring back.

In the Ford car rustless steel is used for the radiator shell, cowl strip, head lamps, tail lamp, hub caps, petrol tank cap and radiator cap. The metal is purchased by the Ford Motor Company from several concerns. How the drawing operations are accomplished without annealing is illustrated in the manufacture of radiator shells in the Company's Rouge plant at Dearborn. The drawing solution, which is applied before the first drawing operation, is composed of a definite quantity of lithaphon, cup grease, sulphur, talcum powder and paraffin oil, thoroughly mixed. The oval piece of metal, after passing through this solution, is drawn into the shape of a pan four and a half inches deep in an ordinary toggle press of about 250 tons, using the same drawing speed as that required for ordinary steel. There is an air attachment adjusted to 35 pounds per square inch on the knock-out pad which also locks the blank to the drawing punch to prevent the metal skidding while being drawn into the die. To prevent scratches and score marks, the space between

the walls of the die and the punch is the thickness of the rustless steel plus .007.

In drawing rustless steel more pressure is required on the draw rings than is the case with ordinary steel. In order to lessen this pressure it is necessary to have double draw beads on the die. The edge thus left on the " pan " after the drawing operation is subsequently trimmed off. The draw die and rings are made of special cast iron of close grain, as follows : carbon, 3.25 ; manganese, .45 ; chrome, .70 ; nickel, 2.00 ; silicon, 1.25. This special cast iron, after being cast and machined to shape, is treated as follows : heat to 1,550 degrees Fahrenheit and cool in air ; then heat to 900 degrees Fahrenheit and again cool in air. Brinnell hardness should be 288 to 311.

To get the best results on draw dies, all drawing surfaces are finished with a stone instead of an emery polishing wheel. The space between the die and the draw ring is very smooth and constant as small indentations on the surface will pick up and cause scratches and scoring more readily on rustless steel. The draw punch is made of chrome non-shrink air hardening steel sections, seated in a cast iron punch shoe. These punch sections are hardened as follows : They are heated to 1,350 degrees Fahrenheit then transferred to a furnace of 1,900 degrees, allowed to soak at 1,900 degrees, and then hung on a wire and allowed to cool in air after which they are heat treated to 980 degrees Fahrenheit, one hour for each inch of thickness of section.

There are seventeen operations in the forming of the radiator shell. After the oval piece of rustless steel has been drawn into the shape of a pan four and a half inches deep, the edge is trimmed off and the pan goes into another press where the decorative pattern is pressed into it. The next operation indents the edge in which the hood tape is placed, the next cuts out the end of the pan which forms the bottom of the radiator shell and the next cuts out the pan's bottom thus making the opening in the front of the shell into which the radiator is fitted. In subsequent operations a hole is cut in the top of the radiator inflow pipe, another is cut in the front for the crank and a small strip is spot welded in the top of the shell for reinforcement. After the final forming operation the shell is placed on an overhead conveyor which carries it to the polishers. The shells, arranged in groups on polishing machines, are given a rough buff with a 180 mesh abrasive, followed by a 200 mesh emery and then a buff of 244 mesh emery which brings out the lustre. The shell then receives its final polishing. Surplus pieces from the bottom and end of the pan are utilised for making smaller parts. From the surplus from each radiator shell there is enough metal to make one crank hole cover, one lamp case, one tail light body, one tail light door, two cowl lamp bodies and two hub caps and some other smaller parts.

It has been said that many plants exist under the control of the Ford Motor Company, but it must not be imagined that they are all exactly similar in the nature of their activities. There are, of course, many manufacturing and assembly plants at which complete vehicles are assembled, partly assembled, and partly manufactured, but there are other plants which are devoted to the manufacture of a few items only. An outstanding example is the manufacture of wheels at the Hamilton plant, who produced during 1929 no less than six million steel one-piece wheels for distribution to other plants. Mention should also be made of several hydro-electric plants depending for their power upon waterways, by the side of which they are situated, and producing anything from 25 to 10,000 h.p., the items manufactured being many and varied according to the strategic position of the plant, local production facilities, labour conditions, and similar considerations which have decided their nature.

Wages.

Probably the most important problem that faces the production engineer is the system of payment to employees. Piece work systems, time rates, and many variations of them have been tried and are still in existence, but not completely satisfactory.

The policy of our Company can be found in the statement by Mr. Ford that wages are more a question for business than for labour, and are more important to business than to labour. Low wages will break business very much more quickly than labour. The old theory which still persists in business is that the rate of wages depends upon the bargaining power of the worker as against the monopoly power of the employer. Under that theory labour unions arose and organisations were begun with boycott strike, and lockout as the weapons. There is no standard wage except that set by the energy, ability and character of all who are engaged in the business, the basic fact emerging is that the standard wage is what management and industry can make it. Upon managers more than upon political economists rests the responsibility of furnishing data for the new theory of wages. If we set ourselves to the payment of wages, then we can find methods of manufacture which will make high wages the cheapest of wages, and that keeps us always on the drawing board finding ways and means to improve methods in every direction, in buying, in making, in selling, in transportation, so that prices may be lowered and higher wages paid. A wage based on a standard of living is destructive, for it implies that all men are alike and can agree as to how they want to live. Any attempt to fix a so-called living wage is an insult to the intelligence of the employer, as well as the workers. We do not know what the right wage is, perhaps we shall never know, but it only clogs progress to try to fix wages without the facts. The world has never ap-

proached industry with the wage motive—from the angle of seeing how high wages may be—and until we have had some experience in that line we shall not know much about wages. The right wage then, is the highest wage the employer can steadily pay.

Some years ago the Ford Motor Company paid wages according to the recognised current district wages, and production costs were similarly about what could be expected from such conditions. Then the Company decided to pay much higher rates than were customary at that time, and there were almost immediately indications of the remarkable success in the reduction of production costs which have been achieved since that time.

Steady and thoughtful application of the increasing rates of pay to the employees were responded to by results which were not only proofs of their economic soundness, but went much further than that in showing definite and profitable progress. To take a fairly clear cut example. In August, 1920, a general advance was decided upon for all employees, from 2s. 3d. to 2s. 9d. per hour. At this time a piece of work, which we will call the "Equipped Chassis" was produced in 29 hours 17 minutes, at a total cost of £4 8s. 6d. By March, 1921, the cost had diminished to about 27½ hours, and in money £3 15s. 0d. In May of the same year wages were again advanced to 2s. 11d. per hour, and by September of the same year the time had become reduced to 25 hours, and the money cost £3 14s. 5d. Comparison is interesting therefore. At 2s. 3d. the cost was £4 8s. 6d., whilst at 2s. 11d. the cost was £3 14s. 5d.

To take an example showing that this theory is not necessarily only applicable to our specialised product. During the war years, amongst the many things produced at the Manchester factory we undertook the manufacture of an article known as "The Exploder Container Tube," a shell part made from sheet steel by a series of deep drawing press operations. This article, of which there had to be made about 175,000 weekly, was produced in our shops by workers getting on an average about twice the rate per hour paid by other manufacturers of this particular article. It is interesting here to interpose that other manufacturers complained that the job could not be made to pay at the price which was paid for them by the Government department concerned. Our experience did not by any means bear this out, we, on the contrary, finding that there was a sufficient margin of profit. When this job was in full swing, however, it was decided by the management to increase wages to all employees by 3d. per hour, but in order not to disturb industrial conditions then prevailing, the advance was given in 1d. stages, at two monthly intervals. It was found that after the addition of each of the 1d. advances to the men, the cost of this item came down and stayed down. At the same time, it can be positively affirmed that nothing whatever was done in the matter of improving tools or speeding up of any kind, the inference being that the

result was entirely due to the good will and eagerness of the employees who benefited by the advance in wages.

It is on record that when Mr. Ford, in 1914, decided to increase the rate of pay from 2.83 dollars per day to a minimum rate of 5 dollars per day, it was found when this somewhat revolutionary proceeding had been in operation a sufficient time to enable the accountants to obtain accurate costs, that the cost of the product was actually 15 per cent. less at the higher rate than it had been at the old and lower rate. Many more instances could be given, but a few of the more notable ones have been quoted, since the system in its entirety is applied to our shops and is operating in the manner generally described previously in hundreds of less notable, but equally definite, instances.

Minute costs are the common currency in all Ford workshops, and mean in simple language the number of pieces produced per unit of time, *i.e.*, 60 pieces per hour would mean that the minute cost of the part would be one minute each. Where the pieces are produced at much greater rates than the instance taken, the cost per piece becomes some decimal part of a minute. By means of thiss ystem the actual money cost is entirely segregated from the time cost so far as the workers and departmental foremen are concerned, while the money cost can easily be determined by the accounting department when required by taking into consideration the average wages rate of the department.

This system has great advantages in avoiding complicated calculations. It is the custom in our factories to switch men from one department to another according to the needs of the moment, so that it would not be uncommon to find a highly skilled tool maker working at a task which is ordinarily done by a worker of no special ability and calling for no more than ordinary intelligence, and while the wage rates paid to these two individuals vary in accordance with our wages rates for such classes of labour, the foreman who has borrowed the tool maker is not embarrassed by the necessity to consider his rate of pay, the minute cost only, or as previously explained, the actual time expended on the job being his sole concern. A further advantage is that comparisons are easily made by this means with other plants without the necessity for complicated calculations involving other currencies, etc. By this means also we are able constantly to keep in touch with the parent plant, who have achieved minute costs which border on the miraculous.

The story of the acquisition of the Company of the D.T.&I. railroad is worth telling. It was found that this railroad was laid in territory of much strategic importance for the outlet of the Company's manufactured product, and as the service from this railroad was not good, it was ultimately decided to acquire it. Its history up to that point had been a most unsatisfactory one

as although the railway had been in existence for about 20 years, it had been a source of loss to its owners, and was in such unsatisfactory condition as to have been justifiably referred to as a "streak of rust." After acquisition by the Company, housecleaning started, rolling stock was brought into more satisfactory condition, and incidentally considerably added to, the executive carefully revised, the workers put on to the Ford hours and rate of pay, and in six months the railway was showing satisfactory profits and was faced with considerable pressure of work in the volume of traffic to be handled.

Close attention is paid to the conservation of natural and national resources, and considerable amount of research and capital have been applied to the production of useful by-products from waste material, and one or two notable examples are well worthy of mention. Moulding and core sand, for instance, are salvaged not for their intrisic value, but because of the saving of freight and handling. Waste oil is salvaged, and what is unfit for either lubrication or rust-proofing is burnt for fuel. Old fire-brick is broken up and re-worked. Waste paper, and refuse of a similar kind which would represent something of a problem in its disposal, are collected and dumped at a paper mill situated conveniently, and there worked into cardboard for cartons for the shipping of spare parts and similar purposes. At one of our large plants, the wood salvage department saves about 90 million board feet of timber per annum, and although conservation rather than cash profit was the original aim, it is now self-sustaining. Our River Rouge plant is probably the best example of the kind amongst all our plants, and probably stands pre-eminent. The by-products plant, for instance, raised the value of every ton of coal brought in by nearly 25s. The process of making direct castings from blast furnace metal saves approximately £2,000 a day on the basis of 2,000 tons of metal poured. The sintering plant reclaims 50 tons of blast furnace dust per day. Slag from the blast furnaces is conducted while still hot from the furnace under a stream of water granulates it and delivers it to a cement manufacturing plant which produces something like 2,000 bags of cement per day.

Salvage.

It is perhaps worth while dwelling for a few moments on the general salvage methods. The vast size and scope of the Company's activities at our largest plant, for instance, means that in the course of a single day material rejected would amount to enough to run a good sized factory for months. Hundreds of tons of iron and steel turnings and sheet metal scrap, thousands of broken tools, damaged plant equipment, large quantities of belting, pliers, wrenches, shears, braces, bits, hammers, drills, gauges, chucks, dies, jigs, fixtures, and so on *ad infinitum*, find their way to the salvage department and are repaired and returned to stock. The

salvage department has a record of every operation in the plant, and exactly the size and kind of tools used there. By this means it can tell whether or not there is a possible use for a damaged tool, whether it can profitably re-work to a smaller size, or finally whether it is beyond further useful life. This is also generally true of most of the tools handled. All tool steel is classified and sorted before re-working. Pipes, valves, and similar steam fitting apparatus are re-conditioned, the saving from this source alone running into a considerable amount in the course of a year. Metal scrap, such as copper, brass, lead, aluminium, babbitt metal, solder, steel and iron, is sorted out according to its classification and returned to the appropriate place for re-melting and re-working. The following figures which refer to by-products are impressive.

By-Products, 1929.

From the coking process alone was produced: 14,910,336 gallons of coal tar; 17,450 tons of ammonium sulphate; 16,249,475 gallons of motor benzol; 19,761,769,000 cubic feet of gas; 1,298,057 tons of coke.

By-products in the Rouge plant include: 713,450 barrels of Portland cement.

The coal tar was burned as fuel; the ammonium sulphate sold for fertiliser; thousands of motorists bought Ford benzol; the Ford Motor Company consumed part of the gas, the remainder being disposed of to a gas company.

By-products derived from the northern Michigan hardwood lumbering district comprised, in part: 20,721 tons of charcoal briquets; 2,754,399 pounds of hardwood pitch; 528,045 gallons of wood alcohol (known under the trade name of CP Methanol); 699 tons of calcium acetate; 1,126,382 gallons of ethyl acetate.

During 1929, 22,178,673 square feet of plate glass was manufactured. The paper production for the same period amounted to 5,054 tons. Rouge produced 391,374 gross tons of pig iron in the blast furnaces and 440,910 gross tons of ingots in the open hearth. 3,226,733 tons of coal were mined by the Company in 1929.

Trade Schools.

Trade schools for boys have been in existence in some of our shops since 1916, and an institution of this kind has recently been installed in our Manchester factory. The school from the start has been governed by three cardinal principles:—(1) that the boy shall be kept a boy and not turned into a premature man; (2) that the educational training is to go hand in hand with the industrial training; (3) that the boy shall be trained to a sense of responsibility by working on articles which are intended to be used for production, nothing being done merely for practice.

In a general way the system is divided into sections in which

one week is spent in the class rooms and two in the shop, and so closely is the work related that the students are able to master their work in much shorter time than is possible in most educational institutions, the whole plant being virtually either text book, laboratory, or workshop according to the needs of the moment. Lessons in mathematics become the familiar shop problem and practice. The educational course includes English in its usual branches, mechanical drawing, mathematics including trigonometry, physics, chemistry, metallurgy, and the ordinary workshop operations in all their many aspects.

The instructors are men chosen not only for their ability as teachers, but also for their talent in understanding boy psychology. There is no school on Saturday, and at our earlier established branches each boy enjoys three weeks holiday with full scholarship allowance. A special thrift fund is added to the pay envelopes, which must be deposited in a savings bank and kept there intact until he leaves the service of the Company, and so long as the deposits are made regularly, the payment is continued. The result is that as a boy graduates he is the master of a highly paid trade by which he may earn enough to continue his education if he so desires. In any case, he is skilled enough to command employment anywhere, although he is first offered a position with the Ford Motor Company. It is a feature that inasmuch as the boy has earned his way through his educational period, he need feel under no obligation after he has graduated, though naturally most of them prefer to work for the Company. It will probably be needless to add that there are never any vacancies occurring for which there are no applicants.

Production Figures.

The Company is probably best recognised for its production of cars, trucks and tractors, although it has already been hinted that these are by no means the limits of its production, and in fact, in many directions it is the largest producer in the world of commodities with the production of which it is not associated in the minds of most people. It can, however, be asserted that the Company is world famous in connection with the production of the Lincoln car, and aeroplanes. Some recent production figures will probably prove interesting. A new record of production for the Ford Motor Company was obtained during April this year, when surpassing a daily total of 9,000, the average reached the colossal figure of no less than 9,500 per day, the highest day's total being 9,565 cars and trucks. These included 1,195 commercial cars, 1,158 Canadian and export, the domestic total on that day being 8,407, and the total production for the month was 206,340 cars and trucks. Of these, 179,149 were domestic and the remainder exported. For the first four months of 1930 the world production of Ford cars and

trucks totalled 606,410.

Flying.

It will be interesting also to state that one million miles of flying with passengers was completed on April 23rd of this year by the Stout Air Lines Incorporated, flying Ford transport planes between Detroit, Cleveland and Chicago. It is believed that this line was the pioneer in carrying passengers exclusively by air.

Henry Ford.

It is appropriate to close this talk with some reference to the genius who is responsible for the organisation, Mr. Henry Ford. If there is any truth in the statement that an institution is the lengthened shadow of a man, this is surely the finest example of it. Mr. Ford has been—and still is—the presiding genius of the organisation which bears his name, and can, even to-day, generally be found in the research laboratories at Dearborn actively advising and leading the work which is done there.

From whence come the gifts which differentiate a man from his fellow? The origin and conditions of genius are somewhat of a mystery. The fact is, Henry Ford lived the life of an average farm boy at a time when machinery of any kind was seldom found on a farm, but he gave early evidence of mechanical genius much beyond the routine of fields and stables. First a miniature water wheel, then a watch fascinated him as an example of automotive power. Seated in a barn one day he took the watch apart and re-assembled it, every part of the mechanism as clear to his mind as the alphabet. At 13 he was pondering the possibility of attaching an engine to a playmate's tricycle, and it is clear to us now how inseparable was his career from his natural gifts.

Counting from the first car Mr. Henry Ford made, it required 30 years to produce the first five million Ford cars. The second five million required three years and were produced between May 1921 and June 1924. On June 4th, 1924, the ten millionth Ford car was completed, and since that time many more millions have been completed, recital of the production of which would be impressive but probably monotonous.

The profound effect which the development of the Ford car has had on human society has its counterpart in the equally profound effect upon industry of Mr. Ford's ideas of social justice and responsibility. First, the car was the thing—its perfection, its manufacture at lowest cost, its use by millions of people, its spread over the entire inhabited earth—then follow the deserts of those who made that possible, which has its first expression in January, 1914 when the minimum rate of pay was increased to about 25s. per day, while the average was considerably higher than that, the establishment of the eight-hour day, five day week, reduction to the absolute

minimum of Sunday work, the institution of educational facilities for adults as well as boys, employees investment system, and the application of these and of similar benefits in every branch of the Company's activities, including mine, lumber camp, factory, railways and so on, in which there is no rule except that of merit for obtaining the countless higher prizes which this industry offers to serious workers. This, however, does not exhaust a great firm's moral obligations to society. There is a buying public also to be thought of, and patrons have a right to share. Mr. Ford dealt with this question very early in the firm's history by numerous cuts in prices, which were—in effect—the sharing of the profits with the buying public, and it could be shown—although not in the compass of this paper—that the expansion of the Company has not been a charge upon the public, *i.e.*, a new factory, or the securing of natural resources does not constitute a new overhead charge on which the consumer of Ford products must constantly pay interest. With a profound wisdom, Mr. Ford has declared that the money with which a new factory is built, or a new block of material acquired, should not be figured as an additional charge upon the public, and its only proper use is to bring further advantages to the public in that field in which it has been spent. At the time the present model was launched, a little over two years ago, Mr. Ford publicly stated :—

"Nineteen years ago we made and sold the first model T Ford car. In announcing it to the public we said 'We will build a car for the great multitude. It will be large enough for the family but small enough for the individual to run and care for. It will be constructed of the best material by the best men to be hired, after the simplest designs modern engineering can devise, but it will be so low in price that no man making a good salary will be unable to own one.'

"If I were starting in business to-day and was asked to restate my policy, I would not change one sentence or one word of that original announcement. In plain simple language it gives the reason for the very existence of the Ford Motor Company and explains its growth.

"The new Ford car is more than a car for the requirements of to-day, it anticipates the needs of future years. I consider it my most important contribution thus far to the progress of the motor industry, the prosperity of the several countries in which it is built, and to the daily welfare of millions of people."

Discussion, Birmingham Section.

(15*th October*, 1931).

MR. W. G. GROOCOCK, President, Birmingham Section: In beginning, Mr. Gorst mentioned the new factory at Dagenham. The figures are something to think about. He spoke of a million square feet, and two hundred thousand units. These units must be something over £100 which means £20,000,000! He then spoke of twenty thousand men. Work that out and you will see it means about £1,000 per man! I mention these figures as showing the tremendous importance of what Ford is doing. Our lecturer mentioned the importance of measurement and of temperature in connection with it. He also mentioned tools and research. There are conveyors, there are salvage plants, which is a very important subject, and above all he mentioned, I think I remember rightly nine thousand odd cars per day. He finished by telling us something of the wonderful personality of Henry Ford. We, as production engineers, owe a great debt of gratitude to Henry Ford. I venture to say that he has coloured all our ideas. We cannot copy him. Very few of us have an opportunity of copying Ford. Where they speak of nine thousand articles of the same type in the same day, and what we are doing is nine hundred different articles in a day. We can dream about what we would do if we had the same set of conditions as Ford, and in doing so we are becoming better production engineers. Henry Ford was working by himself, and his success has been due to the fact that he has been able to handle the thing by himself—he has not had to have a Board of Directors swaying him. His policy has been Ford policy, and he has been able to put it through. We have over here in England also one or two very successful men. They are not Henry Fords, but they are successful men in their line. They started as working men and handled the thing in their own way—and we are proud of them.

MR. GREGORY: During last June I had the pleasure of going round the Ford Manchester works, and I do not know whether I saw right, but there seemed to be only one assembly line, and at the end of that assembly line was a man with a piece of chalk and he chalked up what it was to be, coupe or sedan. At the same time they were assembling the light commercial Ford and, I think, the thirty-cwt. commercial vehicle. If that was being done on one short assembly line, it was certainly a remarkable achievement, at the rate of about two and a half minutes per vehicle.

MR. WHITEHEAD: The lecturer mentioned a temperature of sixty-eight degrees in the testing rooms. That seems to be a high temperature to work in. I should like to know if they make special arrangements with clothing, etc., to enable people to work easily. I think sixty degrees is quite sufficient to work at a pleasant rate.

MR. BOWEN: Is it the intention of the company to close the

Manchester plant when the Dagenham plant is opened?

MR. COWILL: The lecturer mentioned conveyors. I should like to ask what type of conveyor is used for glass manufacture?

MR. PRESTON: The lecturer mentioned that increased wages bring down costs. Would it be asking too much to go into more detail? Is it due, shall I say, to the thankfulness of the employees for receiving extra remuneration that they are much more careful, or just what is the reason? How far can we go with increasing wages to reduce cost? It might be easy for us to accept higher wages, but whether we could guaranteee the reduced costs is another matter.

MR. J. D. SCAIFE: First of all I want to thank Mr. Gorst for his excellent paper, both for himself and as a deputy of Mr. Henry Ford. It has been an example to all of us. He has been showing light car production, but I think we, as production engineers, ought to give Mr. Gorst our very best thanks for this paper and for the information which has been given to us. I myself have had the pleasure of going through the Ford works twice, as well as some other of the automobile factories in the States. The most impressive thing, to my mind, was the sales force, rather than the manufacturing force. It seems to be that when you can guarantee such sales as the Ford Company's, eighty per cent. of the difficulty is done away with. It does not seem to be a very difficult task to manufacture cars like the Ford Company make them if the sales are large. On the other hand, the sales force could not sell in such quantities if they were not made so cheaply. It is co-operation between sales force and manufacturing force which has put the Ford Company where it is. When I was going through the Ford Company's works in the spring of last year (I hope Mr. Gorst will not mind my saying this) I did not think, on the whole, that they were any more efficient than some of the other large motor factories. There seemed to be too many men on some of the operations. I saw an inspection bench where men were packed elbow to elbow. I do not know whether that was a temporary measure or whether it was permanent. If it was permanent, it did not seem to be the proper thing. On the assembly line, also, there were also twice as many men as were occupied. I imagine that they were waiting for larger outputs to come along, and the manufacturing efficiency was not so high as was expected, and that the men were waiting for cars to come along that did not materialise.

Henry Ford, when he started this business with the model "T" had the field to himself, and must have made a tremendous profit. Now, as against people like the General Motors, Morris Motors, and the Austin Company, he is not going to have it all his own way as he had earlier. He is going to have to cater for the public, not like when he said people could have any colour they wanted so long as it was black. It seems to me that the biggest venture

Henry Ford made was when he put down the present plant with the market as it is. I should like to ask Mr. Gorst how many cars they would expect to make at plants like those in the States before those plants are paid for ? It cannot be many years before the entire chassis will have to be changed, plant will have to be re-designed. Most of the special machinery will be useless and it will take the best part of a year to get on to another chassis. It seems to be rather a venture. I wonder just how far it was safe ?

MR. J. PEARSON : I should like to raise the question of gauge tolerances, and to know if the manufacturing gauges have the same tolerances as the inspection gauges ?

MR. SCHOFIELD : You have some remarkable production methods. I should like to know how those are obtained, whether you have central scientific departments which organise and collect all the valuable information, whether it emanates from the Ford laboratories, or whether you work to suggestions from the machine tool maker, who has undoubtedly a very great share in your success ? I hope you will give us some idea of the type of man or department that handles it, and the means by which they arrive at it.

MR. WILMARTH : I should like to know whether, in the Ford works, there is any organisation for looking after superannuation ?

MR. GORST, replying to Mr. Gregory concerning the assembly line and the numerous types of cars : Mr. Gregory is perfectly right in what he says. We have only one main assembly conveyor at Manchester. We are supposed to be producing only one or two types, but the number of types and specifications we can produce, and do, is ninety-six. Several additions have been made which make the total much greater. We are actually accomplishing that, and it is not easy. It can be done and it is done in a way that would probably commend itself to you, though there is nothing very wise about it. It simply means that we have to have certain individuals whose business it is to begin the minor assemblies a long way back, it may be two-and-a-half, three, or even four hours back along the line. These have got to determine several hours before, the kind of car it is going to make next. To have everybody there doing that would lead to chaos.

We fix it this way. The most typical thing is the one by which everything else is guided. In our case we have decided that since there are bodies of every colour, and several frames to each body, as they come from the machines we may more or less grade them according to sales line requirements which have been forecasted not less than four days before. The axle therefore decides the frame and other details. The car gradually grows so that by the time the chassis has arrived ready for the body, it meets the correct body on the body line. If a mistake does happen to be made, it means that a chassis has to be run off without receiving a body, but that rarely happens.

Mr. Whitehead raises the point about temperature in constant temperature checking rooms and is of the opinion that 68° is too high. I do not quite agree. We find 68° is a suitable working temperature, and I have never yet heard any complaints. In any case, 68° was probably decided when C. E. Johannsen was taken into the service of the Ford Motor Company and became an active member of its research staff. He brought with him many of his ideas, and naturally, he is an authority on all subjects connected with gauges—deservedly so. Mr. Whitehead suggested that the temperature is too high, but it is the first time I have heard it.

Mr. Bowen wanted to know whether we were going to close the Manchester plant. Well, I will tell him, but not in the way one might expect. Some few months ago, I had the pleasure of going round the Manchester plant with Mr. Henry Ford himself. I have known Mr. Ford from many different angles but on this particular occasion Mr. Ford was just a particularly genial old gentleman who was not anxious to talk about business except in a desultory sort of way. We talked about Irish politics, Shakespeare's birthplace and such things as that, when Mr. Ford asked me " How far are we from London ? " " Two hundred miles " I replied. He said " Oh, yes, that is just about right. It is just about the distance it ought to be from the Dagenham plant. I think we will use this plant for building trucks, or some other section. I do not know what we will do with it, but anyway, we will use it." May I say, I do not just remember a Ford plant being closed down, through the necessity of having to revise its manufacturing operations. The exact opposite is true. I remember having quite a dust-up with the Power people not so very long ago, when these rumours were about of moving to Dagenham. They wondered if it was quite safe to put in the extra power I was asking for. I said " Well, you can take my assurance that, so far from our needing any less, in six months from now I give you my word we shall come back to you for more cables," all of which proved to be true.

Mr. Cowill asked what sort of conveyor we used for the manufacture of glass. I have explained that the conveyor was the product of expereince and close application by one of the Ford engineers. It is not any particular type of conveyor, except that it is a roller type, very much in plan like the bed of a planing machine, and, if I remember rightly, it has the usual groove type bed, but apart from that there is nothing very special about it. It has a welded cast-iron bed built up in sections, of course carefully aligned. It is made by the Ford engineers, as indeed much of the unique plant has to be made. Anything that is off the usual track of machinery or power plant or anything of that kind has to be produced by the Ford engineers. As a matter of fact, in the power house at the Rouge plant, which generates 500,000 h.p. (eight 35,000 h.p. turbo-generators), the plant was designed and built

entirely by Ford engineers, and at the time they were built they were the largest generators in the world.

Mr. Preston mentioned wages. I should have been very disappointed if I had not been asked a question about wages. The question Mr. Preston raises is a very interesting one. There is no doubt at all, from my experience, which extends over a number of years, that if you take the average worker that you get from the labour market, and treat him in the way that we treat our men, saying, " Now, look here, get busy with this and do the best you can ; the more you do the more we will pay you,"—until you have done that, you have not explored possibilities at all. I remember taking a gardener on in the radiator department. I talked with him from time to time and asked how he was getting on. I asked him how many he was doing. " Twenty-six," he replied. " Do you mind," he asked, " telling me how many you expect me to do ? " When I replied " Seventy-five," he thought it was utterly impossible. As a matter of fact, when I took him off that particular job he was doing 115 quite easily. We start a man. In the first few months his production is low, his fingers are clumsy, and not efficient, and then he picks up, his dexterity increases, and as long as there is the bait of increased pay for increased production, that man will never fail to go after it. I never yet met a man who would not. Some two years ago, we started an entirely new scheme. We knocked off working time from what it had been to a lower rate. Then we said to the men " You know what your usual production is. You are going to work several hours less (actually it was eight hours less in the week) but if you give us the same production in forty hours as you used to give us in forty-eight we will pay you the same amount for it." It was astonishing the the number of men, who were already dexterous men, who were getting a very good rate of pay, who qualified for the increased pay. It is about 95-98 per cent. due to good-will on the part of the worker, provided you remove all extraneous influences away from him. I may say we have no trade unions in our shops : there are no such things as shop stewards.

Mr. Scaife gave us quite a long list of questions. The sales question is undoubtedly a very important part of the production engineer's business. At Manchester we, like most of you people, I expect, fight very fiercely with the sales department. The scrap is constantly going on. As a matter of fact, I am one of the worst of the warriors, but do not let us put all the burden on the sales department. Sales resistance increases according to the character and saleability of the product. When Mr. Ford started, he had not the market that Mr. Scaife has in mind. That did not exist. He had to start with more handicaps than any other business had to start with. Lots of people would not have anything to do with what they called the " infernal machine." They gradually became interested.

In a country like America, with all its vast distances, the motor did, naturally, appeal, and Mr. Ford got in with his great venture long before any of the other manufacturers saw the possibility. The great thing was, he recognised the thing to do was to make a car at a price within the reach of the multitude, and he has always said that every price drop means a constantly increasing class of purchaser, which has been proved absolutely by the firm's history. Mr. Scaife mentioned a very good point—the source of the many labour-saving methods. I do not know that we are different from most other people except that, possibly, we go into these things a little more vigorously than most people do. If an employee has anything that he thinks of interest to us, he is sure of a hearing, and if it appeals to the people concerned it will be adopted. There is no hesitation on our part—no question of "Well, we think it is all right, but just at the present time money is tight, and we do not think we ought to incur additional expense." If we think it is a money saver, it is bought, and we are always buying the products of the brains of the whole world. Under those conditions, how can we help but put in a lot of efficient machinery, and well-organised, labour-saving tools? We do not claim to have the monopoly of brains in the Ford factory. When a machine-tool maker has made a tool for us, and we are satisfied with it, we begin to speed it up. The machine-tool maker says we must not do that—the machine is specified to do so-and-so. We say "All right, machine-tool maker, we absolve you from any responsibility," and proceed to speed it up. It always does it!

I am surprised to hear the old story crop up about having any colour you like so long as it is black. There was a time (and I do not suppose any of you want to claim that Mr. Ford has not made mistakes occasionally), when to make the standard car with many multiples of types could not possibly be considered, and further, as we were making something like eight to nine thousand cars per day of the standard type, so long as people were still anxious to have black cars, we had to make them. Some time ago, Mr. Ford saw that he would have to change his views, and he has just swung to the opposite extreme. There are now quite a multiplicity of types.

Mr. Pearson raises the very good point of gauge tolerances. I have something very interesting to tell you in that connection. The work gauges and inspection gauges do coincide—they are alike. We have one of the most difficult inspection departments in the world. The standard of our inspection department is probably more difficult than is the case with any other organisation in the world. We have a number of men there who are absolute. If the inspection say it does not go, it does not go. It is no use the executives sending down word "That goes," and saying "Off with his head!" The least important member of our inspection depart-

ment can stop the job if he can show that the production is not up to the inspection quality required. I think that is a great ideal that we all talk very piously about. In our shop, it exists. Of course, if an inspector of no great importance does it, then the chief inspector goes along and says "Are you sure about it?" A little committee gets round to find out if he is right, and if he is wrong, he is gently told that he has made a mistake. But until his mistake has been proved, he is absolute, and I cannot tell him "No," or at least, I won't.

I think I have already said, in answering Mr. Scaife, how production methods are obtained. While we obtain our ideas from the same source that you do, we have men constantly on the drawing board trying to improve plant, but I think the great thing is this, that if an idea is found to be not so good as a new one that is discovered, there is no hesitation about scrapping the old one. With a production like ours, with the amount of money represented by work in progress, passing through our shops at all times of the day, if you can find a method that saves a fraction of a minute on any particular piece in production, we can easily spend a lot of money and have a balance on the right side. One of the best ideas we have had, one of the most profitable, was made by a man who stood leaning on a sweeping brush one day. He said to the foreman "I think, if you had an extra set of holes in between those you are punching, you will save a lot of brass." The engineering department was told about it and seized on the idea and it was put into operation. If I told you how much that idea saves, you would not believe me. We also make it easy for a man to come along with ideas. In most shops it is one of the hardest things in the world to get through an idea and to get it put into operation. First of all, he is afraid of getting in the wrong with the foreman, who usually does not like individuals bringing him an idea which he ought to have thought about himself. This is the way we have eradicated this difficulty. If an individual comes along with an idea, we hear about it, it is put into operation and proved to be profitable, he is given a permanent increase in wages. The foreman is not worried about the fact that we think he ought to have thought about it. The foreman, as well as the individual gets the rise, and we find that the foreman is never anxious to take credit away from the man who originated the idea. A charge-hand told us of a little device, one day, for a magazine filler—the simplest possible thing—and when it was explained we wondered why we had never thought of it years ago. It cut out quite a lot of work, and we gave the man an advance of 3d. per hour.

Mr. Wilmart asked about superannuation. We have nothing in the way of superannuation or bonus schemes, or anything of a philanthropic nature at all. Mr. Ford does not agree with it. He believes, and I think rightly, that we pay our men quite enough,

and that they do not need it.

MR. J. A. HANNAY proposed a vote of thanks to Mr. Gorst, which was cordially adopted.

Discussion, Coventry Section.

(12*th November*, 1930).

MR. A. J. AIERS : I should think Mr. Henry Ford has really studied psychology, as otherwise I cannot see how one man could have built up such a large organisation, and I should say he has been able to pick his various managers, etc., who are able to carry on the work for him. At the present time I should say he can do it because of the huge outputs, and also the fact that he can draw on his own raw material. At the beginning he could not have been in that position, and I should like to know whether he was troubled the same as we poor people in Coventry are at the start, and to what you attribute his rapid rise. You mentioned the checking of the sizes of the various parts at a standard temperature. I believe some manufacturers in England go a step further and test the parts at a working temperature, in other words, the various parts will contract, but not equally, and it is better to test at the temperature at which the parts work. I had the pleasure of going over the Manchester works and saw the operation of finally burnishing the crankshaft bearings. While I hardly agree that the limits are fine at the start, it looked a beautiful bearing when it came out. In regard to conveyors, would you tell us which point you think they score on ; firstly, transport of material, or whether more advantage is obtained in definitely controlling your supply or stocks of flowing material. I know it does all of these, but which helps most ? You also mentioned that in one shop there were electric tools for screwing up the nuts, and the next slide showed pneumatic tools. Why two ? Are there certain jobs on which the electric is better than the pneumatic ? I believe that at the Ford works it is customary to change labour about, and I should like to know how the men take to that. Is it done in England ? In regard to the increase in pay, was the pay increased first, or was the output increased at the start, which enabled them to give higher pay ? You showed us the radiator shell and mentioned that it had about seventeen operations. I believe that is done on stainless steel without annealing. That sounds marvellous, because I thought that the trouble due to work hardening is very great, but this has been overcome. Is there some secret in that ?

MR. GORST : Your questions are very excellent. To begin with, Mr. Ford is the greatest psychologist in the world. His understanding of the human animal is absolutely unique. He understands the people who work for him and have enabled to him to obtain such

a prominent position, and does not forget that rich prizes are available for the men who have the energy to go after them. Mr. Ford started exactly like the poor individuals start in Coventry, with the same handicaps, and probably greater. He had to borrow 5,000 dollars in his early manufacturing career to get going at all, and ultimately it cost him rather over 13,000,000 dollars to pay off that debt. He had to struggle with exactly the same conditions as any other pioneer, but he had tremendous vision and unswerving purpose.

We have men at the present time in the States who, if there is such a thing as a super-man, are super-men, and of course, Mr. Ford must have recognised that fact when those men were ordinary pattern makers, or whatever their jobs were. One of the greatest men we have at present time had to first learn how to spell when he was made a foreman in the Ford factories. As his opportunities increased he grew with them, and was able to become what he undoubtedly is—a super-man controlling hundreds of thousands of men.

In regard to the constant temperature and variation of the various parts, you are perfectly right. The constant temperature we use has been fixed as the standard set by Mr. Carl Johannsen. I believe him to be the greatest authority on standards in the world; he has made gauges which are to a millionth part of an inch. Mr. Johannsen discovered the secret of making gauges. The ordinary gauges we use measure to one-tenth of a thousandth of an inch; if you measure a hair from your head with a micrometer it would measure about two thousandths of an inch. Regarding temperature, this is an important factor in the equation. In order to get accurate working parts it is vitally necessary to check them to size at a temperature which is known, because if it is up or down a few degrees it can easily upset the calculations which you have set.

Referring to conveyor advantages, it is true we have the advantages to which both you and I have referred. Whenever a conveyor can be used we have always found it economical. There have been times in the factory where conveyors have been suggested, and I have thought that that conveyor savoured of giving the material a ride, but I have never put in a conveyor which has not had advantages. I should say that probably the chief advantage of conveyors is that they cut out pedestrianism. There is more money spent and lost through pedestrianism than through any other cause that I know. It is true we have electric and pneumatic tools, and the reason is that at one time we had not found an electric tool which would give us the satisfaction we wanted; pneumatic tools were the next best. With the right kind of electric tool it has the pneumatic tool beaten to a shadow, because pneumatic tools are costly, and there is also the installation of expensive plant in providing compressed air. Electric tools are undoubtedly

the best and they are being steadily installed all over the plant.

In regard to the switching of men, I suppose that at our factory this is unique. Sometimes it is convenient to send out tool makers into the shop. It is constantly necessary to do things of that kind, and switch men from one department to another. If we put in a tool maker who is getting about 4s. an hour, where the rate of pay is 3s. it does not matter to the foreman as long as he gets the same number of pieces of work. This makes the switching of men quite possible and quite convenient, and a great deal of this is done. Regarding the pay, we do not get the work from the men before we increase the pay. When this was first done they were getting trade union rates of pay. Our Directors decided that this should be increased to twice as much, or a little more, and that the minimum rate should be 2s. 3d. per hour. This had marvellous results, and if there are any employers here I commend it to them. We immediately found that our manufacturing costs were less at the new rate than they were at the old. I want to assure you that there was not a single wheel turned one revolution faster, nor any alteration made to the tools. It was due entirely to the interest, eagerness and willingness to respond to the treatment they were getting. It was then found that the cost of the entire product was 15 per cent. less at the new rate than at the old. We do a little annealing on rustless steel. Some operations call for a certain amount of annealing.

MR. SYKES : I noticed the absence of youth labour in your works. Can you tell me at what age you put a youth in the works ? To what extent do you give ad lib to your inspectors, and do you mind saying what type of individual, or what ability you claim for the inspectors ? Will you kindly tell me what you do to ensure that your tools, gauges and fixtures are kept in such a condition as to keep producing accurate work. Do you have to do the same as we do here—find out only when you produce scrap ?

MR. GORST : We do employ youths, but only in a very limited way. We do not practice the apprenticeship system in the way that it is usually practised. Boys are selected for various reasons and put in the schools, they are given a certain time and their particular aptitude is discovered. Some may make tool makers, pattern makers, welders, etc., but it is all done in a systematic way, because we try to give them an academic training in the way it should be given by capable people. We have men whose business it is to do nothing else but look after the boys. Alternate weeks they spend a whole week in the school under capable teachers learning all about the business. Our system is absolutely complete. We also have adult schools, but not in Manchester. In America men can go into the adult schools and learn to become thoroughly skilled men. You are wrong in assuming that we only make one model ; we make several models, and it is matter of extreme difficulty to keep all

those models catered for in the usual way, that is to say, we probably have ten or twelve variations of one model, and we have various models. I should say that at the present time we are turning out cars to three hundred different specifications. This morning I went on to the inspection line, and the foreman was tearing his hair ; he was absolutely wild. The chief inspector was with him, and an inspector who had rejected a number of pistons. The reason why those pistons were rejected was because they were about one gramme light over the inspection limit. The inspector had instructions to put his hammer through them, and they were broken up. I thought the foreman was perfectly right to be annoyed, but after much thought I believed the inspector to be right. If we start out to achieve a certain limit and we are going to break it, it might never have been imposed, so I permitted the inspector put his hammer through the pistons. I told you that to show that we mean what we say. The men who do the inspection jobs are chosen from the ranks, so are the men who do anything else. Everyone is given an opportunity if aptitude is shown. Nobody is supposed to interfere with the inspector. The inspection of gauges is very much as you find it in your own shops. We very often get trouble owing to the fact that in all the thousands of gauges used, someone has omitted to notice that one has worn beyond the limit.

MR. SHAW : In regard to the question of enamel work, with such fine limits I take it that there is quite a lot of lapping used in the throws of the crank, gudgeon pins, etc., and I should like to know if the lapping machines installed are giving satisfaction. The question of inspection seems to be assuming large dimensions in the discussion. You mentioned a figure of three per cent. Can we take it that this is the percentage as expressed to the cost of labour throughout the factory.

MR. GORST : We clean the material to be enamelled in the way you expect it to be cleaned, that is to say, by washing machines. Machines carry the articles through a steam conveyor. They come out of the machine heated up to a high temperature, men receive them, wipe them off and the heat quickly dries them ; they are then ready for rubbing down. Most of them have to be rubbed by paper until they are quite bright. The lapping machines are working quite satisfactorily. The cost of inspection is included nowadays in the cost of production. We used to keep the inspection. time separate, and we could see exactly how much our inspection was costing us, but that was changed.

MR. E. W. HANCOCK (Chairman of the Council and President of the Coventry Section who presided) : When we speak of production methods, it is always important for us to remember that production methods are based upon the main policy of any particular company for which we may be working, and that we must adjust our ideas regarding methods of production to that particular

policy. Regarding the question of production methods, we have to bear in mind those methods which are effective and those which are efficient, as we have in this country, small but very fruitful soil to be tilled, and in many cases it is impossible to work these small shops to the last degree of efficiency, but nevertheless, if we run them effectively, it is still possible to run on a profitable basis. In referring to a recent talk by Sir Josiah Stamp on "Modern Directorship and Management," we are informed by him that privately owned concerns in the last 40 years have diminished from 70 per cent to 30 per cent. I raise this point, as it indicates the necessity for better understanding of functions of control as most works nowadays are controlled by a hired staff who have not the same individual and personal spur that the privately owned concern has. Bearing this in mind, therefore, there is one thing that we can learn from the bigger organisations such as Ford, namely, that by a careful analysis of allocations of functions, we can apply quite a good deal of this knowledge when organising concerns in this country. We have seen many impressive photographs to-night of methods of production, methods of handling, etc., but despite all these impressive sights, one of the best measures of the firm's efficiency is to take the square footage required to produce £1 of productive labour, and I will be very interested to know if Mr. Gorst can tell us what the square footage per £1 is in Manchester, and what is the expectation at the new works at Dagenham. If we can have this figure, I think many of you would be able to console yourselves with the fact that although you may be doing nothing very spectacular, you may be working very efficiently indeed. Since the question of wages and increasing employment has been raised, I would like to quote an opinion which was recently expressed by a prominent engineer in this country. The opinion expressed, was, that "Better productivity and lower costs must inevitably mean less workpeople employed." I do not agree with this opinion myself, and consequently therefore, I would like to have Mr. Gorst's opinion on this matter. We also hear from time to time, that if production was our only trouble in this country, our troubles would be very slight indeed, but I would like to point out that not many years ago production was our trouble as we found a great difficulty in meeting the demands put upon our workshops, and I can only suggest in the meantime our competitors have been very busy. It is quite clear that there is no object in making quantities of articles at low costs if they cannot be sold, and I quite agree that we may suffer from a little internal pressure and possible over-production, but I consider the cure is rather one of increasing our sales activities rather than to reduce production efficiency. I was very interested when discussing these matters with one of our leading engineers in this country, to learn that he spent approximately six months abroad,

and that his particular firm were exporting at least 50 per cent. of their production. I think this signifies to a good extent, the, way in which we should endeavour to release this possible internal pressure to which I referred. Making reference once more to Mr. Ford, I think one of the outstanding lessons which he has taught us, is to go out into the world with a view to collecting data as to possible markets, and to base the commodities and quantities of production upon data gathered by actual contact and investigation of the markets. This policy of pioneering salesmanship as I call it, sets the first major policy of a manufacturing unit, and if we wish to prevent over production in this country, we should not overlook the question of exports.

Mr. Gorst: Continuing to produce when there is not a ready outlet. You mention this, but not the alternative. What are we to do; sit down and not produce, or put a brake on? I disagree with any suggestion that over-production is responsible for the present-day depression. When we were producing in Manchester, by the same methods which I imagine have been referred to by the speakers here, we had less than 500 men, and our output was what could be expected. By developing continuous improvements our output has gone up considerably, and at the present time we employ about 3,000 men. In the Detroit plant Mr. Ford had about a dozen men when he started, at the present time at the Rouge plant there are nearer 200,000 men. In the meantime there are 88 plants scattered all over the world. The intensity of the production is going up and up and up.

If you read Mr. Ford's two books—"My Life and Work" and "To-day and To-morrow," you will find the economics of the questions raised by Mr. Hancock. These are not theories but concrete facts. Production at the present time is causing difficulty because of the dislocation of the markets, owing to causes which I submit are due to the upset of the industrial conditions throughout the entire universe. My experience with the Ford Motor Company has meant this; that as we improve our methods and decrease our costs, invariably it has made more work for more men, and we are going on doing it. We have proved it so very definitely throughout our entire organisation. You mention about the square footage of the factories. This is an incidental which is subjected to many other considerations. After laying down a plant to build so many, we have had to build many more. When we design a factory, we design it with the idea of not covering any more area than is required for the contemplated output. In regard to the market, you mentioned that Mr. Ford went out and discovered his market. Possibly Mr. Ford does grab as much as possible, but can you tell me who does not? It is vision of that kind that has made this organisation. We are going to build a plant at Dagenham which is to be based on, and built on the accumulated experience of the most marvellous

manufacturing organisation the world has yet seen. Englishmen in England are going to have the benefit of 25 years' experience All the good things are going to be put in, and Englishmen are going to run and work it; it is going to be an English product. That is going to be a most valuable contribution to industrial development of the country. This point should take us out of the narrow point of view that "This car is of American origin." It is going to be produced in this country by Englishmen, and it is going to be a marvellous contribution to the industrial life of the country.

MR. SALTER: Firstly you mentioned that the basis of comparison of progress is now a question of time and not cost, and I take it that development has been taking place in the last three or four years. From an individual point of view in Manchester, is that comparison made with figures supplied from Detroit, and do you compare that time basis with those on the Continent? Mr. Hancock mentioned the question of production per area per square foot. It seems to me that you have disregarded the area necessary to produce a given article but concentrated on the question of labour; you have sacrificed area but conserved labour. I gather that the main fact is the conservation of labour. After cleaning and before enamelling, do you thoroughly inspect any metal necessary, and will you give us some idea of the percentage of area in comparison with the product? You mentioned electric versus pneumatic tools. You have probably tried out high frequency tools. What has been your experience of these as applied to stud setting?

MR. GORST: The minute cost has been in operation not less than 11 years, and I think it is about 12 years since we first changed over from money cost to the minute cost system. We have these minute costs from all our factories, and each month I am given a good sized folder which tells me the cost of a car in Manchester, also our various European plants, and one or two of our American. I am sorry you stress the question of area and labour, because it is not so important as one might be led to believe. Our Manchester factory was not built by the Ford Company. It was acquired by the Company about 20 years ago, and as time has gone on we have added and re-organised. About 40,000 yards have been added during the last few years. It is not done from the point of view of conserving space because we have not sufficient. It is a question of minimising pedestrianism. In regard to enamelling, it would be impossible to give you a figure because it varies so tremendously. We use twice as many men one day as another, and men have to be brought in according to the needs of the moment. The reference to the high frequency tools was very good. With the electric tools it was found that when you have run up a nut to its ultimate position, you came to a stop. We have slip rings which enable the tool to slip round without actually pulling the tool right up. A cordial vote of thanks to Mr. Gorst concluded the proceedings.

Discussion, Joint Meeting, Birmingham Section and Wolverhampton and District Engineering Society.

(*15th December*, 1930).

MR. GEO. STEVENS, President, Wolverhampton and District Engineering Society, in opening the meeting, introduced Mr. W. G. Groocock, President of the Birmingham Section of the Institution of Production Engineers, who would, he said, make some remarks on the subject of affiliation of local engineering societies with the Institution of Production Engineers.

MR. GROOCOCK: It gives me great pleasure to be here and to have the privilege of addressing this joint meeting of the Wolverhampton and District Engineering Society and the Birmingham Section of the Institution of Production Engineers. No doubt a number of you are aware that the production engineers met together with your committee and arranged this meeting. The reason I can tell you in a few words. For some time past there has been murmuring, from men who ought to know better, that there are too many engineering societies in this country. Personally, I do not believe it, and our members do not believe it. We believe that the engineering societies in this country have in the past done good work and are doing good work now, and will do good work in the future. We, in the Institution of Production Engineers, consider, however, that there is room for closer co-operation between various societies, and so our Council have lately drawn up regulations which will make it possible for affiliation to take place between local societies and our Institution. It was with that idea in mind that we arranged with your committee for this joint meeting. This is a time of rationalisation or mergers, but while we do not want mergers we want all the co-operation we can get, and we arranged this meeting in conjunction with your committee so that we might get a little bit closer together, as the first step on the road to affiliation. Affiliation between a district society like this and a national society such as the Institution of Production Engineers should be of great advantage to both. I have been a member of a number of engineering societies in various places in England, and as a private member of these societies, I have always felt the need for some closer bond with organisations that specialised along other lines. Under affiliation, members of affiliated societies will have opportunities of attending our lectures, and of taking part in the discussions following the lectures. Their officers will receive the publications that we issue, and can select from these publications any lecture they like for reading and discussion before their own members. There are many other points about affiliation which would, I am sure, be of great help to the local societies, but I will not delay you by

going into them now.

Mr. Gorst then presented his paper, which was accompanied by lantern slides and followed by a cinematograph film.

MR. STEVENS: I think you all know now, or don't know, how the Ford car is made. I could not but think, whilst listening to Mr. Gorst, and particularly seeing some of the slides and the motion picture, of the time when I went round that plant in 1927. I came away somewhat in the same state of mind as the old lady the first time she visited the zoo and saw a giraffe. She turned to a friend and said, "I don't believe it!" I saw them making five motor cars per minute, and I think you will agree with me that wants some believing, and yet it was actually being done while I was there. That is accounted for by the wonderful organisation that exists in Detroit. I doubt whether any one can really get any idea of the extent of it unless he stays there for some considerable time and makes a close study of its wonderful ramifications. Mr. Gorst said, in the course of his lecture, that when we saw the factory on the screen we would see the birth of the Ford car, but if he does not mind, I will suggest that I saw the real birth of the Ford car. I was in a motor car running alongside the railway, and on the other side of the railway, as high as a four or five-storey building, and as far as I could see to the right and to the left, was a mass of steel and iron work from ships that had been broken up for the purpose of being melted down for the manufacture of Ford cars. I think that was one of the most astounding things I saw at the River Rouge works. There must have been millions of tons of metal work, and I should suggest that that really was the birth of the Ford car. No doubt you will have got from the motion picture some idea of what it would be like in the foundry. When I was in the foundry it was really one of the most remarkable things I had ever seen in my life. Speaking of one part of the foundry, where the work was going on on conveyors, and the metal was being poured into the moulds, practically the whole of the work was being done by negroes. The heat, of course, in the place rather made the coloured men necessary, but I can assure you that I do not think I have ever seen anything that can possibly be such a near approach to Hades as that particular foundry. It gives me particular pleasure this evening to propose on your behalf a very hearty vote of thanks to Mr. Gorst for an interesting and instructive lecture.

MR. W. G. GROOCOCK: I know nothing of Hades—perhaps Mr. Stevens knows more about it than I do—but I have no doubt that it is warm in those foundries. Having been in two other of the foundries, I can also say that they are undoubtedly clean, and that is something to say of a foundry. Mr. Gorst mentioned that it had been rumoured that Mr. Ford said history was "bunk." If he did, he added something else to it, I am sure. Mr. Ford does

not accept that anything cannot be done. He says it can be done. and if history tells him it cannot be done, he would be quite right in saying that history was " bunk." The figures Mr. Gorst showed on the screen are something to think about. First, think of the new factory at Dagenham. A million square feet—two hundred thousand units—put them at £100 each, that is £20,000,000. Twenty thousand employees, that is £1,000 per employee per year. One million square feet and that amount of money means £20 per square foot per year. Not many of us are getting £20 per square foot off our factories ! The great thing about Mr. Ford is that he does not accept, as I said just now, the fact that a thing cannot be done, but the finest thing of all, I think, is his one idea that by making the article cheap he is making the market for himself. He has done that—he has made a cheap, undoubtedly a good, article at the price and has made a market, therefore his selling must be fairly easy. Mr. Ford is one of the men I admire most because, although many of the things he is doing to-day have been done before, he was the first man to apply them to engineering. It gives me great pleasure to second the vote of thanks to Mr. Gorst for his very interesting lecture.

The vote of thanks was adopted with acclamation.

Mr. Gorst : May I first deal with the points raised by the two speakers. I can quite understand your Chairman's attitude of mind when he said he was like the old lady who just didn't believe it. I thought he was going to tell us that story of the American who, on first meeting a certain animal, not a giraffe, exclaimed, " There ain't no such animal ! " I have had the privilege of spending considerable time in the Detroit factories, and one begins to lose the capacity for surprise, in seeing the marvels one runs into day by day. Production figures were lightly touched upon by your Chairman. A new record of production for the Ford Motor Company was obtained during April this year when, surpassing a daily total of 9,000, the average reached the colossal figure of no less than 9,500 per day—the highest day's total being 9,565 cars and trucks. These included 1,195 commercial cars, 1,158 Canadian and export, the domestic total of that day being 8,407, and the total production for the month was 206,340 cars and trucks. Of these, 179,149 were domestic and the remainder exported. For the first four months of 1930 the world production of Ford cars and trucks totalled 606,410. You will agree with me that these are very impressive figures. Time was when Mr. Ford thought it an achievement to produce quite a small number of cars per week. I remember hearing with a good deal of uproarious glee, many years ago, the project that we were going to produce twenty-five cars per day at Manchester. It looked hopeless—a wild, unlikely figure, but now we think nothing of doing 250 cars per day at Manchester, and one hundred is an ordinary day's production.

Mr. Stevens referred to the colossal quantity of material that had been acquired in the destruction of 199 ships which Mr. Ford bought from the United States Shipping Board. These ships were bought by Mr. Ford because they represented at that time a national white elephant. Nobody knew quite what to do with them. Nobody would undertake the task of breaking these ships up, and then Mr. Ford bought them at quite a good figure, and set to work to scientifically pull them apart and use the material in the production of the car. These ships are now all destroyed, most of the material has been salvaged and put to good use, but there are piles built up in the River Rouge yard which it is estimated it will take roughly about ten years to use up. It is being used up at quite a rapid rate, but there is a tremendous amount of it even now, at least a mile and a half long stacked quite forty feet high, but I can assure you that does not represent the birth of the car. The car was in production long before that task was undertaken.

That was a gesture, by Mr. Ford, of national importance, and he has lately been responsible for another, not quite so big from one point of view, but possibly bigger from another—the destruction of old cars. At the present time, in the Detroit factory, there is a floor devoted to the demolition of old cars which are brought in by the company, irrespective of their make or condition, at about twenty dollars each. Men with acetylene torches and similar appliances are busy pulling these things apart, and they are going into the melting pot. It is quite a national asset that such a thing can be done.

I was amused by the reference to Hades. Though we all admit that Mr. Ford is certainly a wizard and a genius, he has not yet found how to make a live, everyday foundry as cool as, say, your summerhouse. I am afraid heat is inseparable from the work that is going on. You are wrong in assuming that the heat is so great they have to use coloured men to do it. That is not the reason at all. The reason is that white men were not available in sufficient numbers. As you probably know, America has quite a problem of its own in the trouble created by the mixed races, and of course these people have to live, and have to have such work as their intelligence fits them for, and it is a fact that black men were not there because it was the kind of job suits them best, but simply because they were the only kind of labour available. There are quite a lot of white men mixed up with them.

The last time I had the privilege of walking round our Manchester factory with Mr. Ford, he made reference to that very question. He turned to me and said, "There is one thing I like about this place. Everybody round here looks like somebody," which was his way of saying that the class of men that we had in the place were men who looked as though they were intelligent men and contrasted enviably with the kind of labour they had to use over

in the States.

I like Mr. Groocock's reference to Mr. Ford and the word " bunk." I do not want that to loom too large, but I wanted to deny the rumour that I saw widely reported in the press that Mr. Ford had said that history was all bunk. He is one of the greatest students of history the world knows at the present time. An important museum owes its existence entirely to the energies of Mr. Ford. Thomas Edison is an inseparable friend of his, and quite recently on the fiftieth anniversary of the birth of electric light, Mr. Ford had the whole scene recreated with as much of the original building as could be found, which had been spread all over the place. Edison, Francis Yale, and some of the original operatives foregathered to celebrate the anniversary. That would be quite impossible to a man who regarded history as " bunk."

Mr. Groocock touched on the question of areas. Well, we do not give it much attention, it is one of those little things which is allowed to look after itself.

Space is always precious, and in our Manchester factory a number of years ago we had quite a few employees, less than five hundred, and a comparatively small place. We have gone on increasing in the space that we have acquired, but never has there been a time when we had enough. At the present time we are at our wits end to know what to do with a new department we are trying to install. I found in talking to Mr. Groocock, and others, that many people possess a deep-rooted idea that I am talking about an American production. I would give a good deal to eradicate that idea from your minds. It is true that the Ford car is very largely an American car, but the Ford car, as you know it, is an English production to a very large extent, and probably to a greater extent than many cars which are supposed to be of English production. It eventually will be an entirely English production, produced by Englishmen and in such quantities as we propose to make, a contribution to the industrial development of this country. When Dagenham is going, we shall see something approximating very closely to an industrial miracle. Dagenham at one time was a hopeless swamp, almost waterlogged, on which the tide rolled twice in the course of a natural day, and was apparently irreclaimable ; the home of wild birds, in other words, just simply a pestilential swamp. That is where we are going to build this factory which is going to represent a wage bill of the magnitude referred to by Mr. Groocock—a tremendously important contribution to the industrial well being of this country, for which we ought to thank Mr. Ford very heartily indeed. Naturally, it is expected that a part of the production will be shipped to the Continent.

A word about policy. Mr. Ford's has always been, and if I were seeking to attribute the wonderful growth and success of this institution to any one factor, this is the factor which I would introduce

to you with the utmost possible confidence, and that is the policy of the company in always reducing production costs and at the same time reducing the cost to the public. Mr. Ford was not out for making profits out of mechanical transport, but with the end in view of producing a car at the lowest possible price, and servicing it also at the lowest possible price. I once took considerable trouble to find out how much it would take to buy spare parts for the old model "T." It was possible to buy a complete set for fifteen per cent. more than the original purchase price. As production costs have come down, the cost to the public has come down, Mr. Ford's policy being first of all service, and incidentally it is a fact that any time you introduce a price drop you introduce your product to a tremendously greater class of buyer—that is commonsense. If my address has been instrumental in helping forward the affiliation of these two societies, I am very gratified.

Discussion, Glasgow Section.

(*24th February*, 1931.)

Mr. King asked what measures were taken and how much spare labour was available to cope with breakdowns.

Mr. Gorst said that breakdowns were of great seriousness and wherever possible they had duplicate equipment, but where this was not available they had to scurry round and find every means possible to have things put right. This, he said, was always a most critical period. He instanced a breakdown in Manchester that morning. Men in assembly department had to come down to half speed, but there was sufficient stock on the main floor and shipping tables to keep factory going for rest of the day and that during this time the breakdown was being put right for next shift. They had no spare labour; if they had it would add considerably to overhead cost. It was found that certain departments were running in advance of required production, men from these departments were placed in other departments not so favourably situated.

Mr. Pollit asked what percentage was required to take up men who were ill or men falling out of line due to necessity; what pressure men were working at; and what provision there was for getting men immediately started at starting time? He also said that no stock had actually been shown between manufacture and assembly and asked the position in regard to this.

Mr. Gorst, referring to the question regarding men working at too great a pressure, said there was no truth in this. He also referred to suggested extreme monotony in their works and stated that this was not the case; the men in their employment took as much interest in their work and found time for creating as much as in any other situtation. The pressure was by no means greater

than the men could bear ; the Company would not tolerate that. They had, he believed, the safest shop in the British Isles, the percentage of accidents being less than in any other engineering shop in the country, and this would not be possible if the men were working at too great a pressure. Regarding the question of starting time, he considered this should be exactly on the set time, not ten minutes before or after, but right on the time, the same remark applying to stopping time. With regard to stock of parts between operations, he said they did not believe in carrying a large stock of parts between operations. This was kept at a minimum, and if it was found that stock was accumulating in any department then that department was closed down.

Mr. Buchanan said it had been mentioned that they worked in certain cases to one 1/10,000th and that gauges were inspected in a controlled temperature room. He asked if parts were manufactured under controlled temperature.

Mr. Gorst, referring to the matter of varying temperatures, said this was a question that raised certain difficulties. The temperature could not be maintained exactly the same all over, but they tried to do so as much as possible. They were not so familiar with the subject as they would like to be, but meantime they had to deal with matters as they found them although they hoped to know more about it soon, and in any case progress was being made towards controlled shop temperature. He assured those present, however, that material had to pass gauges to necessary limits in the controlled temperature checking room before going into production.

Mr. Nicholson asked what provision was made for spare parts in jobs going through the shop and how were spare parts procured if short ? We also asked if spares got preference over production.

Mr. Gorst said they knew that a certain percentage of parts would be required for spares but production demands were cut down if necessary and parts taken from shipping tables to meet spares demands which always came first, efforts of course being made to readjust the situation by putting more material into lines affected.

A cordial vote of thanks to Mr. Gorst concluded the proceedings.